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*भारतीय मानक*

# रंग-रोगन कोलतार एपोक्सी, दो पैक, काला तथा भूरा (बेस तथा कठोरक) — विशिष्टि

*Indian Standard*

# PAINT COAL TAR EPOXY, TWO PACK, BLACK AND BROWN (BASE AND HARDNER) — SPECIFICATION

ICS 47.020.01; 87.040

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**BUREAU OF INDIAN STANDARDS**
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

*June* 2001

**Price Group 5**

Industrial Paints Sectional Committee, CHD 031

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Industrial Paints Sectional Committee had been approved by the Chemical Division Council.

Coal Tar Epoxy paint is mainly used as an outer-bottom protective coating for ships which are cathodically protected or as a coating for tanks containing sea water which may be contaminated with fuel oil. When used on outer-bottoms it will be followed by a suitable tie coat and required coats of antifouling paint. Time interval between two coats of coal tar should not be more than 96 h and not less than 16 h.

The mixed paint should be suitable for application by brushing or airless spraying. The paint system is normally applied in three alternate coats of black and brown to steel which has been suitably prepared by abrasive blasting or other approved methods.

When this material is used in a confined space, suitable precautions should be taken to safeguard the health of operators during all painting operations and adequate ventilation provided.

There is no International Standard available on the subject.

The composition of the committee responsible for formulating this standard is given at Annex H.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

# *Indian Standard*

# PAINT COAL TAR EPOXY, TWO PACK, BLACK AND BROWN (BASE AND HARDNER) — SPECIFICATION

## 1 SCOPE

**1.1** This standard prescribes requirements, sampling and method of tests for two pack, black and brown (base and hardner) coal tar epoxy paint intended to be used for protection of ships or steel surfaces, immersed in sea water.

**1.2** The paint system is required to be normally applied in three alternate coats of black and brown to steel surfaces which has been suitably prepared by abrasive blasting or other approved methods.

## 2 REFERENCES

The Indian Standards listed in Annex A contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards.

## 3 TERMINOLOGY

**3.1** For the purpose of this standard the definitions given in IS 1303 and the following shall apply.

### 3.2 Ambient Temperature

**3.2.1** A temperature between 21°C and 38°C, unless otherwise specified.

## 4 REQUIREMENTS

### 4.1 Composition

**4.1.1** The medium of the coal tar epoxy paint shall consist essentially of a suitable coal tar together with an epoxy resin and curing agent. The paint shall be a two pack material. One component (base) shall consist of a suitable epoxy resin along with solvents, pigments/extender and thixotropic agent. The amount of epoxy resin as determined by Annex B shall not be less than 35 percent of the non-volatile vehicle of the paint. Its epoxide equivalent when estimated by the method given in Annex C shall be between 450-500.

**4.1.2** The second component (hardner) shall consists of a suitable coal tar blended with polyamide curing agent along with suitable amount of pigments, solvents and thixotropic additive. The amount of curing agent shall be sufficient to fully cure the epoxy resin to conform to the requirements of this specification.

**4.1.3** The mixing proportion of base and hardner shall be a simple ratio by volume as recommended by the manufacturer.

### 4.2 Keeping Properties

**4.2.1** The paint (base and hardner) shall conform to all the requirements of this standard when tested after twelve months from the date of manufacutre, if the material is stored in original sealed containers under cover at ambient temperature.

**4.3** The coal tar epoxy paint shall also satisfy the requirements given in Table 1.

## 5 PACKING AND MARKING

### 5.1 Packing

**5.1.1** Unless otherwise agreed to between the supplier and the purchaser, the material shall be packed as follows.

**5.1.2** The base shall be packed in mild steel drums of 20 l capacity conforming to grade B2 of IS 2552. The drum shall be fitted with 100 mm inner plugs and a capaseal closure. Drums shall be provided with a strap handle in the centre of the top, not projecting beyond the top rim of the drum. Base shall be packed up to a suitable level, to keep necessary allowance to mix specified proportion of hardner in the base drum to make 20 l of coal tar epoxy paint.

**5.1.3** The hardner for the paint shall be packed in mild steel drums of suitable capacity conforming to grade B2 of IS 2552 fitted with 100 mm inner plug and capaseal closure and shall be fitted with strap handle.

### 5.2 Marking

**5.2.1** Each drums shall be legibly marked as under:

a) Name of the material indicating base and hardner;
b) Indication of the source of manufacture;
c) Batch No., Lot No., month and year of manufacture;
d) Expiry date;
e) Mixing ratio of base and hardner by volume;
f) Quantity of individual component (base or hardner), and finished paint after mixing in litres; and
g) Net and gross weight of material.

## Table 1 Requirements of Coal Tar Epoxy Paint

(*Clause* 4.3)

| Sl No. | Characteristic | Requirement | Methods of Test | |
|---|---|---|---|---|
| | | | Annex | Ref to IS 101 |
| (1) | (2) | (3) | (4) | (5) |
| i) | Preliminary examination | The base and curing agent each shall be in such a condition that stirring easily produces a smooth and uniform material which on mixing shall give a thixotropic paint suitable for application by brushing or airless spraying | — | (Part 1/Sec 2) |
| ii) | Finish | The paint system comprising of 3 coats, prepared on an abrasive blasted steel panel 30 cm × 30 cm or larger and allowed to dry for 24 h after application of the final coat shall give a smooth finish free from sagging and wrinkling | — | (Part 3/Sec 4) |
| iii) | Drying time h, *Max* | | | |
| | a) Surface dry | 4 | — | (Part 3/Sec 1) |
| | b) Hard dry | 16 | | |
| iv) | Flexibility and adhesion | Paint film shall not show signs of cracking or loss of adhesion when tested on 1.5 mm using type 1 apparatus and 6.25 mm diameter mandrel on burnished tinplate panel after 7 days drying | — | (Part 5/Sec 2) |
| v) | Impact test paint system | Paint system, comprising of 3 coats, shall not show signs of cracking, flaking or detachment from the panel or loss of adhesion between coats when tested on abrasive blasted panel, after 7 days drying and facing panel upwards, from 2 m height | — | (Part 5/Sec 3) |
| vi) | Dry film thickness, microns/per coat | 125 ± 10 | — | (Part 3/Sec 2) |
| vii) | Volume solids, percent, *Min* | 64 | — | (Part 8/Sec 6) |
| viii) | Gel time, h *Max* | 40 | D | — |
| ix) | Flash point, °C | Not below 25 | — | (Part 1/Sec 6) |
| x) | Pot life, h, *Min* | 8 | E | — |
| xi) | Resistance to corrosion | The paint film shall not show blistering and break-down and protect the substrate against corrosion | F | — |
| xii) | Resistance to sea water under cathodic protection conditions | To pass the test | G | — |

NOTE — Theoritical spreading capacity of the paint at a dry film thickness of 125 microns is 5 sq m/l approx.

**5.2.2** *BIS Certification Marking*

The product may also be marked with the Standard Mark.

**5.2.2.1** The use of Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

## 6 SAMPLING

**6.1** The representative samples shall be drawn as prescribed in IS 101 (Part 1/Sec 1).

## 7 TEST METHODS

**7.1** Tests shall be conducted as per test methods stipulated in IS 101 and Annexes mentioned in col 4 of Table 1.

**7.2 Quality of Reagents**

Unless specified otherwise, pure chemicals and distilled water (conforming to IS 1070) shall be employed in tests.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain any impurities which affect the results of analysis.

# ANNEX A

## (*Clause* 2)

## LIST OF REFERRED INDIAN STANDARDS

| *IS No.* | *Title* |
|---|---|
| 101 | Methods of sampling and test for paints, varnishes and related products: |
| (Part 1/Sec 1) : 1986 | Test on liquid paints (general and physical), Section 1 Sampling (*third revision*) |
| (Part 1/Sec 2) : 1987 | Test on liquid paints (general and physical), Section 2 Preliminary of samples for testing (*third revision*) |
| (Part 1/Sec 6) : 1987 | Test on liquid paints (general and physical), Section 6 Flash point (*third revision*) |
| (Part 1/Sec 7) : 1987 | Test on liquid paints (general and physical), Section 7 Mass per 10 l (*third revision*) |
| (Part 2/Sec 2) : 1986 | Test on liquid paints (chemical examination), Section 2 Volatile matter (*third revision*) |
| (Part 3/Sec 1) : 1986 | Tests on paint film formation, Section 1 Drying time (*third revision*) |
| (Part 3/Sec 2) : 1989 | Tests on paint film formation, Section 2 Film thickness (*third revision*) |
| (Part 3/Sec 4) : 1987 | Tests on paint film formation, Section 4 Finish (*third revision*) |
| (Part 5/Sec 2) : 1988 | Mechanical tests on paint films, Section 2 Flexibility and adhesion tests (*third revision*) |
| (Part 5/Sec 3) : 1988 | Mechanical tests on paint films, Section 3 Impact resistance (failling weight) (*third revision*) |
| (Part 8/Sec 6) : 1993 | Tests for pigments and other solids, Section 6 Volume solids |
| 513 : 1986 | Specification for cold rolled low carbon steel sheets and strips (*third revision*) |
| 1070 : 1992 | Reagent grade water (*third revision*) |
| 1303 : 1983 | Glossary of terms relating to paints (*second revision*) |
| 2552 : 1971 | Steel drums (galvanised and ungalvanised) (*second revision*) |
| 4683 : 1968 | Chilled iron shots and grits for use in foundries |

# ANNEX B

## (*Clause* 4.1.1)

## DETERMINATION OF EPOXY RESIN CONTENT IN NON-VOLATILE VEHICLE

### B-1 OUTLINE OF THE METHOD

The base component and the mixed paint are examined for non-volatile vehicle. Epoxy content is calculated using these values and the weight mixing ratio.

### B-2 APPARATUS

**B-2.1 Centrifuge** — having a revolution of 8 000 rpm with arrangement for 100 ml glass tubes.

**B-2.2 Oven** — maintained at 100 ± 2°C.

**B-2.3 Furnace** — maintained at 800 ± 5°C.

### B-3 REAGENTS AND MATERIALS

Solvent mixtures comprising of equal parts by volume of methyl isobutyl ketone (MIBK) and xylene.

### B-4 PROCEDURE

**B-4.1** Determine percent volatile matter $V_m$ in mixed paint as per method prescribed in IS 101 (Part 2/Sec 2).

**B-4.2** Determine, to the nearest 0.001 g/ml, the density of base and hardner components of the paint. Calculate their mixing ratio by weight for 100 g of the paint.

**B-4.3** Determine non-volatile vehicle $B_b$ of base component as per method in IS 101 (Part 8/Sec 2).

**B-4.4** Separate pigments of known quantity of mixed paint as per method in IS 101 (Part 8/Sec 2). Heat the pigments in a silica dish in furnace at 800°C to remove carbon black (from coal tar) and weigh the residue. Calculate percent pigments $P_m$ of mixed paint as follows:

$$P_m = \frac{\text{Weight of residue}}{\text{Weight of paint}}$$

## B-5 CALCULATION

**B-5.1** Calculate non-volatile vehicle of $B_m$ of mixed paint as follows:

$$B_m = 100\,(V_m) + P_m$$

**B-5.2** Calculate epoxy resin content in g in 100 g of mixed paint as follows :

$$E_b = \frac{B_b(x)}{x+y}\,\text{g}$$

where $x$ and $y$ are parts by weight of base and hardner for 100 g of the paint.

**B-5.3** Calculate percent epoxy resin (uncured) content in non-volatile vehicle as follows:

$$\text{Epoxy content} = \frac{E_b}{B_m} \times 100$$

# ANNEX C

(*Clause* 4.1.1)

## DETERMINATION OF EPOXY CONTENT (Weight per Epoxide Equivalent) OF EPOXY RESINS

### C-1 OUTLINE OF THE METHOD

The epoxy resin dissolved in a suitable solvent is titrated directly with a standard solution of hydrogen bromide in glacial acetic acid. The hydrogen bromide reacts stoichiometrically with epoxy groups to form bromohydrins. The quantity of acid consumed is a measure of the epoxy content.

### C-2 APPARATUS

**C-2.1 Burret**

The burret tip should be fitted with a rubber stopper of proper size to fit to the neck of the Erlenmeyer flask and the stopper should have an additional small hole to permit escape of the replaced air during titration.

**C-2.2 Magnetic Stirrer** — adjustable speed.

**C-2.3 Magnetic Stirring Bars** — Teflon coated.

### C-3 REAGENTS AND MATERIALS

**C-3.1 Chloroform-Chlorobenzene Mixture (1+1)**

**C-3.2 Crystal Violet Indicator Solution**

**C-3.2.1** Prepare 0.1 percent solution of crystal violet in glacial acetic acid.

**C-3.3 Glacial Acetic Acid**

**C-3.4 Hydrobromic Acid HBr** — 30-33 percent concentration in acetic acid.

**C-3.5 Hydrogen Bromide** — in acetic acid standard (0.1 N).

**C-3.5.1** Prepare approximately 0.1 N hydrobromic acid (HBr) by adding 25 ml of 30-33 percent HBr in 1 l of glacial acetic acid. Standardize at the time of use against accurately weighed 0.4 g of potassium acid pthalate and dissolved by gently heating in 10 ml of glacial acetic acid.

**C-3.5.2** *Calculation*

Calculate the normality of the HBr in acetic acid as follows :

$$N = \frac{W \times 1\,000}{204.2H}$$

where

$W$ = grams of potassium acid pthalate used; and
$H$ = millilitres of HBr solution used.

### C-4 PROCEDURE

**C-4.1** Weigh accurately 0.5-1.0 g of sample into an Erlenmeyer flask of 125 ml capacity . Dissolve the sample in the solvent at room temperature. Use 10 ml of chlorobenzene and 25 ml of 1+1 mixture of chlorobenzene and chloroform mixture. Place a teflon coated magnetic stirring bar into the flask and allow mixture to swirl on magnetic stirrer to effect solution.

**C-4.1.1** Add 4 to 6 drops of crystal violet indicator solution and attach to the rubber stopper on the burst tip. Lower the burret tip to a point above the solution avoiding contamination/contact and titrate with the HBr solution to a blue-green end point with the magnetic stirrer rotating at a moderate speed to allow ample time for the reaction to take place. Titrate to as nearly as possible the same colour at the end point as that obtained during standardization of the reagent.

**C-4.2** Make a blank determination on the reagents in an identical manner.

## C-5 CALCULATION

Calculate the weight per epoxy equivalent (WPE), that is grams of the resin containing one gram equivalent of epoxy groups, as follows :

$$WPE = \frac{1\,000\,S}{N(V-B)}$$

where

$N$ = normality of the HBr used;
$V$ = millilitre of HBr solution used for titration of the sample;
$B$ = millilitre of HBr solution used for the titration of the blank; and
$S$ = weight of the sample used.

# ANNEX D

[*Table* 1, *Sl No.* (viii)]

## DETERMINATION OF GEL TIME OF PAINT COAL TAR EPOXY

### D-1 OUTLINE OF THE METHOD

The two component of the paint are mixed in appropriate proportion and the time for gelling of the mixed paint is recorded.

### D-2 MATERIALS

**D-2.1** Paint can, open top, 250 ml approximately 7.5 cm dia and 6 cm height.

**D-2.2** Wooden probe : Applicator stick approximately 0.25 cm in diameter and 15 cm in length.

### D-3 PROCEDURE

**D-3.1** Mix the two components of the paint in ratio recommended by manufacturer to provide 200 ml of the material. The paint shall be mixed by slow agitation with a stirring rod or mixing paddle to avoid air entrapment.

**D-3.2** Every hourly interval, probe the centre portion of the reacting paint, with the application stick perpendicular to the material surface.

**D-3.3** When the reacting paint no longer adheres to the end of a clean probe, record the elapsed time from the start of mixing as gel time.

# ANNEX E

[*Table* 1, *Sl No.* (x)]

## DETERMINATION OF POT LIFE

### E-1 OUTLINE OF THE METHOD

The two component of the coal tar epoxy paint are mixed in appropriate proportions and the time in which the paint becomes unusable by brushing is reported as pot life.

### E-2 PROCEDURE

**E-2.1** Two components of the paint are mixed thoroughly in ratio recommended by manufacturer to provide 200 ml of the material. The paint shall be mixed by slow agitation with a stirring rod or mixing paddle to avoid air entrapment.

**E-2.2** The paint is examined at hourly interval for its consistency and the time from the mixing till the paint becomes unusable by brush is reported as pot life.

# ANNEX F

## [*Table* 1, *Sl No.* (xi)]

## DETERMINATION OF RESISTANCE TO CORROSION

### F-1 OUTLINE OF THE METHOD

**F-1.1** The method provides accelerated testing procedure for determining resistance to corrosion of coal tar epoxy paint.

**F-1.2** The panel coated with coal tar epoxy paint is examined for deterioration by cyclic test for six weeks. The test comprises of 3 days exposure in humidity cabinet and 4 days in sea water.

### F-2 COMPOSITION OF NATURAL SEA WATER

The natural sea water shall have a *p*H of 7.9 to 8.3 and a chlorinity of not less than 17 parts and salinity of 31 parts per 1 000.

NOTE — The chlorinity and consequently salinity of natural sea water on the Indian coast line is subject to variations due to the monsoon. Dilution occurs during this period, lowering these values considerably. This period usually varies from 3 to 4 months during the year. In the other months, salinity is equal to or even higher than the synthetic sea water but seldom exceeds 36 to 37 parts. This rise in salinity, however, does not have a very significant effect on the test.

### F-3 COMPOSITION OF ARTIFICIAL SEA WATER

**F-3.1** Dissolve the specified amounts of the following salts and make up with freshly distilled water to give 1 l of the solution:

| *Salt* | *Mass*, g |
|---|---|
| Sodium chloride ($NaCl$) | 23.476 |
| Magnesium chloride ($MgCl_2$) | 4.981 |
| Sodium sulphate ($Na_2SO_4$) | 3.917 |
| Calcium chloride ($CaCl_2$) | 1.102 |
| Potassium chloride ($KCl$) | 0.664 |
| Sodium bicarbonate ($NaHCO_3$) | 0.192 |
| Potassium bromide ($KBr$) | 0.096 |
| Boric acid ($H_3BO_4$) | 0.026 |
| Strontium chloride ($SrCl_3$) | 0.024 |
| Sodium fluoride ($NaF$) | 0.003 |
| | 34.481 |
| Water to make | 1 000.000 ml |

**F-3.1.1** The artificial sea water thus prepared on thorough aeration possesses a *p*H between 7.9 and 8.3.

### F-4 PROCEDURE

**F-4.1 Preparation of Test Panel**

**F-4.1.1** Clean the mild steel panels of size 150 mm × 100 mm × 1.5 mm and conforming to type DD of IS 513 by blasting with chilled cast iron grit Grade No. GC 60 at a pressure of 4.2 kg/cm. Smooth down the grit blasted surface partially with emery paper and then degrease it. Apply a coat of the material by brushing to give dry film thickness of 125 ± 10 microns (dry film mass of 200-250 gm/sq.m percent). Allow the painted panels to dry for seven days at standard atmospheric conditions.

NOTE — The grit blasted panel should be painted within four hours of the grit blasting. In case it is not possible the panels shall be preserved properly in a dessicator.

**F-4.2** Seal the edges of the painted panels as prepared in **F-4.1.1** with suitable protective coating (generally paraffin wax is used) to a depth of 6 mm by hot dipping.

**F-4.3** Expose painted panels in humidity cabinet [*see* IS 101 (Part 6/Sec 1)] for 8 h everyday for 3 days (72 h). Panels shall not be removed from cabinet during silent period. At the end of 3 days, panels are taken out and immersed for 4 days (96 h) in aquarium tanks containing sea water with non-metallic support. Aerate the test liquid by a continuous slow stream of air, free from oil or grease, maintaining the temperature at 27 ± 2°C. This cyclic testing shall be continued for six weeks.

# ANNEX G

## [*Table* 1, *Sl No.* (xii)]

## RESISTANCE TO SEA WATER UNDER CONDITIONS OF CATHODIC PROTECTION

### G-1 OUTLINE OF THE METHOD

The paint system comprising of one coat of coal tar epoxy paint applied to abrasive blasted steel panel is exposed to natural or synthetic sea water at a potential of –1 000 mV (SCE) for 6 weeks and the paint coating is examined for any signs of deterioration.

### G-2 APPARATUS

**G-2.1** The apparatus illustrated diagrammatically in Fig. 1 shall consist of the following:

a) A glass or persplex tank fitted with a suitable overflow device to allow the provision of running sea water during the test. It shall also have device to firmly support the test panels at equal distance from centrally placed platinum anode;

b) Platinum anode;

c) Voltmeter, 1.5 V dc fed with a sensitivity of at least 20 000 ohms/volt;

d) Standard calomel reference electrode (SCE);

e) Potentiometer of about 5 000 ohms;

f) Power source, 12 V battery; and

g) Alternatively, an automatic potentiostat circuit may be used.

**G-2.2** Mild steel panel, conforming to type DD to IS 513, size 150 × 100 × 1.5 mm and having a side arm of 100 × 14 × 1.5 mm as shown in Fig. 1. Panel with arm should be cut from the same plate. Welding of arm to panel is not permitted.

### G-3 COMPOSITION OF NATURAL SEA WATER

As per details given in **F-2** of Annex F.

### G-4 COMPOSITION OF ARTIFICIAL SEA WATER

As per details given in **F-3** of Annex F.

### G-5 PROCEDURE

**G-5.1** Prepare a mild steel panels in duplicate, by abrasive blasting as described in **F-4.1.1** of Annex F. After degreasing, fix a self adhesive disc of 16 mm diameter in the middle of one side of test panel. Apply one coat of coal tar epoxy paint by brush on both sides of panel at an interval of 24 h to provide a dry film thickness of 125 ± 10 microns (dry film mass of 200-250 gm/sq.m per coat). Allow the paint to dry in vertical position for seven days under standard conditions.

**G-5.2** After seven days air drying of the paint, the adhesive tape if removed, the edges of the panels are sealed with epoxy resin to a depth of 6 mm and immersed in sea water tank. Using copper wire, connections amongst arm of test panels. Platinum anode, potentiometer and power source are made as per diagram in Fig. 1. By means of potentiometer the panels are maintained at a potential of –1 000 mV (SCE). Throughout the test period a constant supply of aerated sea water is maintained to the tank at such a rate as to provide about one complete change of water in 24 h. Alternatively, the sea water is continuously aerated and changes once a week.

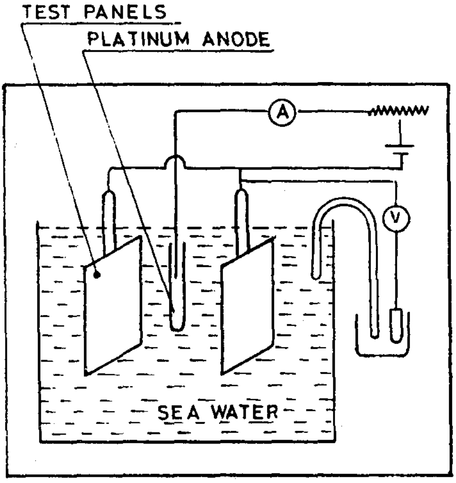

FIG. 1 DIAGRAMMATIC SKETCH OF THE APPARATUS FOR DETERMINING RESISTANCE TO SEA WATER UNDER CONDITIONS OF CATHODIC PROTECTION

**G-5.3** The material shall be deemed to have passed the test if paint on panel, at the end of 6 weeks period, does not show any sign of breakdown, blistering or loss of adhesion. Presence of few blisters up to 1 mm size shall not be cause for rejection.

# ANNEX H

## (*Foreword*)

## COMMITTEE COMPOSITION

### Industrial Paints Sectional Committee, CHD 31

*Chairman*
Shri Ravi Marphatia
14, Orion, Oomir Park, Bulabhai Desai Road, Mumbai - 400 026

| *Members* | *Representing* |
|---|---|
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| Shri V. M. Natu<br>Shri B. A. Pradhan (*Alternate*) | Asian Paints (I) Ltd, Mumbai |
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| Shri S. Ghosh<br>Shri K. Nirmal Kumar (*Alternate*) | Berger Paints India Ltd, Kolkata |
| Shri Raj Kumar<br>Shri S. C. Gupta (*Alternate*) | Bharat Heavy Electricals Ltd, New Delhi |
| Shri S. P. Maitra | Bombay Paints Ltd, Mumbai |
| Shri S. R. Singh | Development Commissioner (SSI) GOI, New Delhi |
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| Dr G. Saha | Engineers India Ltd, New Delhi |
| Shri D. M. Raje<br>Shri K. D. Sawant (*Alternate*) | Goodlass Narolac Paints Ltd, Mumbai |
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| Shri B. B. Pal<br>Shri S. K. Saha (*Alternate*) | Naitonal Test House, Kolkata |
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| Shri Dhirendra Kumar<br>Shri B. C. Chakraborty (*Alternate*) | Naval Materials Research Laboratory, Ambernath |
| Shri P. Kumar | Oil and Natural Gas Corporation Ltd, New Mumbai |
| Shri Shaish Kumar<br>Shri B. B. Sharma (*Alternate*) | Department of Industrial Development, New Delhi |
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*Member-Secretary*
Dr D. K. Chaudhury
Director (Chem), BIS

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